U.S. Fish & Wildlife Service

Pre-Dam Removal Studies of Goldsborough Creek, Shelton, Washington

Western Washington Office
Aquatic Resources Division

Lacey, Washington
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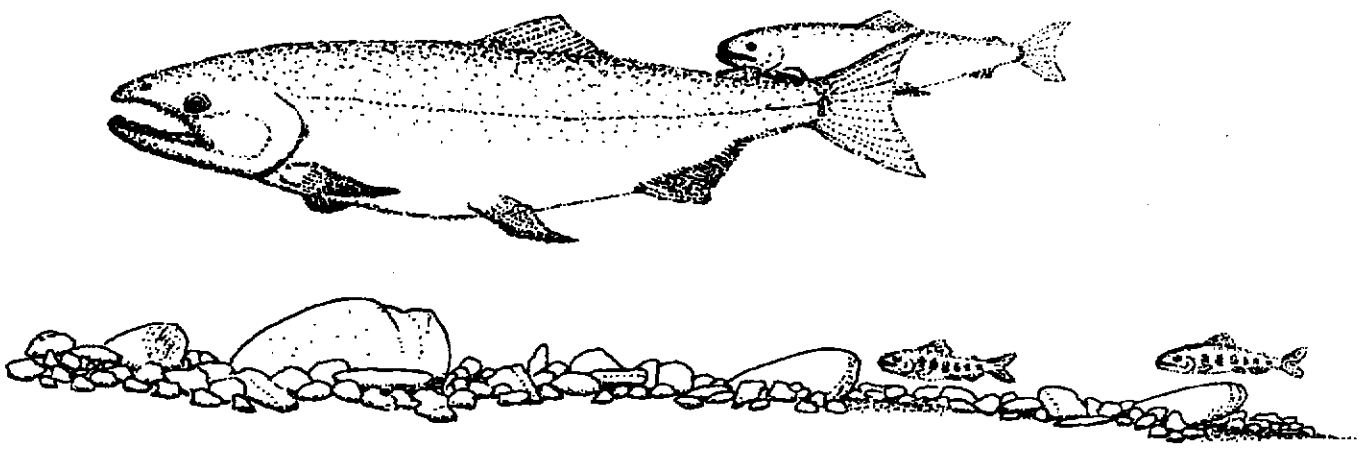

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Introduction

The U.S. Army Corps of Engineers (Corps) recently proposed the removal of a severely deteriorating dam on Goldsborough Creek and restoration of the affected reach. Goldsborough Dam was constructed in 1921 at river kilometer (RKm) 3.5 to provide power to the City of Shelton. However, there is evidence of a dam at the existing location as early as the 1880's. In 1932, the dam was converted to provide water to the local pulp mill until a flood in 1996 damaged the structure beyond repair. At present time the dam serves no useful purpose and the current fish passage system is impassible to a majority of the migrating salmonids in the system.

The current restoration plan is to remove the dam and construct a new stream channel over an 850-meter section of creek. The project would require 61,168 m^3 of fill and several rock sills to re-establish the channel. The new stream bed would have a 1.5% gradient over the length of the project. The purpose of this restoration project is to restore creek conditions to pre-structure status and to restore fish passage into the upper reaches of the watershed.

The Corps granted funding to the U.S. Fish and Wildlife Service (Service) to conduct instream habitat surveys and collect stream health monitoring data in lower Goldsborough Creek and to conduct salmonid spawner surveys in the watershed prior to dam removal. Survey data will be used to determine success of this restoration project by providing comparisons to post-dam removal monitoring data.

Ambient Habitat Monitoring of Lower Goldsborough Creek-1998

Carrie Cook-Tabor and Linda Moore

Introduction

Pacific salmonids are an integral component of the Northwest, supporting recreation, culture and industry. Salmonids are an ecologically important key species in their freshwater and marine environments and the abundance of salmonids is dependent, in part, upon the availability of freshwater habitat. The extensive losses in salmonid populations have led to concern regarding the status of estuarine and freshwater habitats in Puget Sound. Effort has been made to survey many of the salmonid-bearing river systems.

Approximately two miles (RM 4.5-5.8 and 10.8-11.2) of Goldsborough Creek were surveyed in 1993 and 1994 by the Squaxin Island Tribe (Schuett-Hames et al. 1996). Sampling was based upon the TFW Ambient Monitoring Protocol (Schuett-Hames et al. 1994). Habitat surveys, and subsequently, an indication of aquatic habitat condition, were unavailable for the reach most likely affected by the dam removal project (RM 0-3+). The Corps requested that the U.S. Fish and Wildlife Service (USFWS) complete habitat surveys of the affected reach prior to removal of the Goldsborough Creek dam, following the TFW Ambient Monitoring Protocol.

Our objective was to collect information on the current condition of the stream channel habitat in order to monitor changes in the stream channel from pre- to post-dam removal.

Study Site

Goldsborough Creek (Water Resource Inventory Area 14.0035) is 14 miles long, is located in the Shelton Basin, and drains into Oakland Bay in the town of Shelton (Figure 1). The headwaters of the North and South Forks originate from springs, surface drainage and small lakes (Williams et al. 1975). Mean monthly low flows ranged from 20 cfs in September to 395 cfs in February over the period of 1960-1975 (Williams et al. 1975).

Methods

Standard methods described in the TFW Ambient Monitoring Program Manual (Schuett-Hames et al. 1994) were used for the following surveys. The lower three miles of Goldsborough Creek were divided into two stream segments, one below and one above the dam. The upstream boundary was established at the start of the natural stream gradient, above the zone influenced by the impoundment. Discharge was measured at the beginning of each stream segment at the start of the habitat surveys. Surveys were conducted during September and October of 1998.

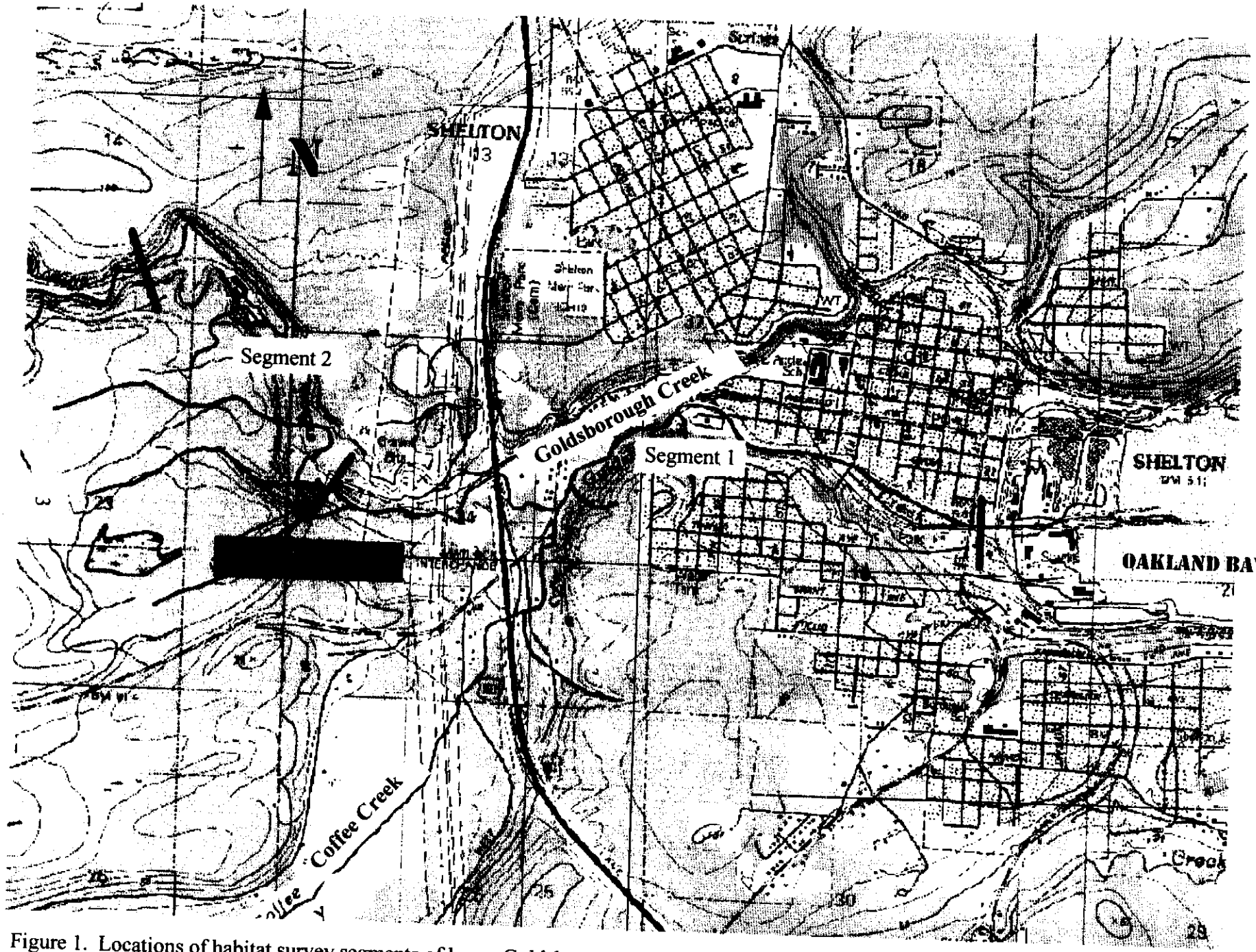

Figure 1. Locations of habitat survey segments of lower Goldsborough Creek, Shelton, Washington.

Stream Segment Sections and Reference Points
The two stream segments were broken into 100-m sections and permanent reference points denoting each section were marked by nailing aluminum tags to large trees. At the reference point locations, downstream and upstream photographs were taken, canopy closure (percent shade) was measured with a densiometer, and bankfull width and depth were also measured.

Habitat Units
Habitat unit surveys were performed following protocol at a sampling rate of 50% of the sections. The 100-m sections within the stream segments were broken into habitat units, consisting of pools, tailouts, glides, riffles and cascades. Lengths and average widths of each habitat unit were measured and the location of the habitat unit was categorized (primary, secondary, and side-channel unit). Pool-forming obstructions were noted and residual pool depths were determined from the maximum pool depth and pool outlet depth. The percent dominant and subdominant stream substrate (sand, gravel, cobble, boulder, and bedrock) associated with the habitat unit was measured.

Large Woody Debris
Within the habitats surveyed, log jams and large woody debris (LWD) were counted and measured following the less-intensive Level 1 method of the TFW protocol, where pieces are categorized but not measured individually. The LWD was divided into four categories (rootwads, or logs of 10-20 cm, 20-50 cm, and > 50 cm in diameter, as described in Appendix C-1), and three zones (within the wetted width, within the bankfull channel, or above the bankfull channel), and counted.

Streamside Structure
The dominant land management practice associated with the creek was recorded, as well as the dominant riparian vegetation along the stream channel, its vegetative stage, and its approximate distance inland (up to a maximum of 30 m). Location, length, and height of mass wasting and cutbanks were also noted.

Data Management
All survey data were entered in a database (Rbase 4.0), error checked, and copied to floppy disks. Reference point photographs were digitally scanned, catalogued, and the resulting zip files placed on a tape. Reference point, habitat unit, and woody debris data were then expanded by sample rate and summarized by stream segment.

Results

The reference point and habitat surveys began on September 19 and were completed on October 21, 1998. A total of 5,028 meters of the creek were surveyed for reference points, 3,428 meters below the dam and 1,600 meters above (Table 1; Appendix A). Instream habitat surveys were performed on half of the 100-m sections within the stream segments (Appendices B-1, B-2, C-1, C-2, D). The average bankfull width below and above the dam was 13.8 m and 17.7 m, respectively. The average canopy closure was surprisingly similar at 60 % below and 61 % above the dam. Stream flows measured at the downstream reference points of segment 1 (below the dam) and 2 (above the dam) were 1.12 cm/s (39.66 cfs) and 0.66 cm/s (23.30 cfs), respectively. Very little rain fell in September and October and stream flows remained within +/- 10% of the above flow measurements during the survey period.

The total number of habitat units, expanded for the sample rate, in both segments was 392, for a total expanded surface area of 53,089 m^2 (Table 2). Pools were the most numerous (152), followed by riffles (97), cascades (56), glides (48), and tailouts (39). Below the dam, riffles had the highest percent of the total surface area at 36 %, while only 22 % of the total surface area above the dam consisted of riffles. Above the dam, pools were not only the most abundant of the habitat unit types, but also had the highest percent of the total surface area at 57 %.

The total number of log jams, expanded for the sample rate, was 44, with the majority of the jams (38) found below the dam (Table 3). The total expanded number of rootwads and logs for both segments was 2,100. The majority of the large woody debris (53.8 %) was categorized as "small logs", followed by "medium logs" (34.2 %), "rootwads" (7.4 %), and "large logs" (4.5 %).

Table 1. Lower Goldsborough Creek reference point survey data summary.

Segment	Cumulative Distance (m)	Sample Rate %	Bankfull Width			Bankfull Depth			Canopy Closure		
			Average	Min. (m)	Max	Average	Min. (m)	Max	Average	Min. %	Max
Below Dam	3428	50.0	13.82	9.30	20.40	0.64	0.35	1.05	60.7	4.0	99.8
Above Dam	1600	48.8	17.72	11.70	27.00	0.51	0.20	0.77	61.9	0	98.8

Table 2. Lower Goldsborough Creek habitat data summary expanded by sample rate.

Cascade							
Segment	Units (#)	Average Length/Unit (m)	Average Unit Width (m)	Average Surface Area (m2)	Total Surface Area (m2)	Average No. Units/100m (#)	% of Grand Total
Below Dam	38	10.6	9.3	98.8	3522.3	1.11	9.9
Above Dam	18	7.8	8.1	62.8	1147.2	1.15	6.6
Total	56	9.7	8.9	87.2	4669.5	1.11	8.8

Glide							
Segment	Units (#)	Average Length/Unit (m)	Average Unit Width (m)	Average Surface Area (m2)	Total Surface Area (m2)	Average No. Units/100m (#)	% of Grand Total
Below Dam	38	24.2	8.3	200.1	7997.6	1.11	22.5
Above Dam	10	24.4	5.1	125.6	1229.3	0.64	7.0
Total	48	24.2	7.6	184.6	9226.9	0.95	17.4

Riffle							
Segment	Units (#)	Average Length/Unit (m)	Average Unit Width (m)	Average Surface Area (m2)	Total Surface Area (m2)	Average No. Units/100m (#)	% of Grand Total
Below Dam	68	22.2	7.7	171.3	12927.0	1.98	36.3
Above Dam	29	16.4	8.0	131.0	3843.0	1.79	22.0
Total	97	20.5	7.8	159.3	16770.0	1.93	31.6

Tailout							
Segment	Units (#)	Average Length/Unit (m)	Average Unit Width (m)	Average Surface Area (m2)	Total Surface Area (m2)	Average No. Units/100m (#)	% of Grand Total
Below Dam	12	7.9	9.3	74.2	1000.0	0.35	2.8
Above Dam	27	5.3	8.4	44.1	1224.9	1.67	7.0
Total	39	6.1	8.7	53.4	2224.9	0.78	4.2

Table 2 (cont.). Lower Goldsborough Creek habitat unit summary expanded by sample rate.

	Pool (all types combined)							
Segment	Units (#)	Average Length/Unit (m)	Average Unit Width (m)	Average Residual Depth (m)	Average Surface Area (m2)	Total Surface Area (m2)	Average No. Units/100m (#)	% of Grand Total
Below Dam	90	15.7	6.2	0.67	98.0	10150.9	2.63	28.5
Above Dam	62	21.8	6.7	0.77	146.9	10047.1	3.85	57.4
Total	152	18.2	6.4	0.71	117.9	20198.0	3.02	38.0

Summary		
	Below Dam	Above Dam
Habitat Units per Kilometer	7.00	20.51
Habitat Units per Bankfull Width	0.10	0.36
Pools per Kilometer	5.25	16.67
Bankfull widths per Pool	13.79	3.39

Table 3. Goldsborough Creek large woody debris, all zones.

Zone 1							
Segment		Log Jams	Rootwads	Small Logs	Medium Logs	Large Logs	Total Logs
Below Dam	Sampled	19	55	297	158	18	473
	Expanded	38	110	594	316	36	946
Above Dam	Sampled	3	15	158	107	17	282
	Expanded	6	31	324	219	35	578

Zone 2							
Segment		Log Jams	Rootwads	Small Logs	Medium Logs	Large Logs	Total Logs
Below Dam	Sampled	0	4	32	22	1	55
	Expanded	0	8	64	44	2	110
Above Dam	Sampled	0	0	46	37	8	91
	Expanded	0	0	94	76	16	187

Zone 3							
Segment		Log Jams	Rootwads	Small Logs	Medium Logs	Large Logs	Total Logs
Below Dam	Sampled	0	3	10	16	2	28
	Expanded	0	6	20	32	4	56
Above Dam	Sampled	0	0	17	15	1	33
	Expanded	0	0	35	31	2	68

All Zones							
Segment		Log Jams	Rootwads	Small Logs	Medium Logs	Large Logs	Total Logs
Below Dam	Sampled	19	62	339	196	21	556
	Expanded	38	124	678	392	42	1112
Above Dam	Sampled	3	15	221	159	26	406
	Expanded	6	31	453	326	53	833

Table 3 (cont.). Goldsborough Creek large woody debris, all zones.

Summary					
		Total # of Pieces	% of Total Pieces	LWD per Channel Width	LWD per Kilometer
Below Dam	Rootwads	62	10.0	0.5	36.2
	Small Logs	339	54.8	2.7	198.3
	Medium Logs	196	31.7	1.6	112.6
	Large Logs	21	3.4	0.1	10.5
	Total	618		4.9	357.5
Above Dam	Rootwads	15	3.6	0.3	19.2
	Small Logs	221	52.5	5.0	283.3
	Medium Logs	159	37.8	3.6	203.8
	Large Logs	26	6.2	0.6	33.3
	Total	421		9.6	539.7

Acknowledgments

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Appendices

Appendix A. Goldsborough Creek reference point survey data, September, 1998.

Segment	Reference Point	Cumulative Distance (m)	Bankfull Width (m)	Bankfull Depth (m)	Canopy Closure
Below Dam	1	0	12.80	0.48	50
	2	100	14.10	0.68	86
	3	200	14.20	0.72	67
	4	300	14.00	0.72	87
	5	400	15.50	0.73	44
	6	500	11.50	0.65	99
	7	614	12.40	0.72	58
	8	700	12.20	0.74	70
	9	800	14.10	0.47	92
	10	900	13.65	1.05	72
	11	1000	10.20	0.76	87
	12	1100	13.30	0.54	77
	13	1200	13.85	0.63	51
	14	1300	13.40	0.80	71
	15	1400	10.70	0.63	73
	16	1500	15.20	0.69	89
	17	1600	16.30	0.42	31
	18	1700	12.20	0.35	31
	19	1800	15.00	0.49	19
	20	1900	11.35	0.60	96
	21	2000	11.70	0.84	83
	22	2100	18.00	0.61	22
	23	2200	9.40	0.85	22
	24	2300	20.40	0.78	4
	25	2400	9.30	0.56	89
	26	2500	16.90	0.56	25
	27	2600	11.30	0.61	99
	28	2700	13.60	0.67	39
	29	2800	15.10	0.58	18
	30	2900	15.50	0.44	22
	31	3000	15.50	0.58	14
	32	3100	12.00	0.78	92
	33	3200	15.10	0.52	73
	34	3300	16.30	0.40	64
	35	3400	14.60	0.61	67
	36	3428	16.70	0.60	82
Above Dam	0	0	27.00	0.32	0
	1	100	18.40	0.66	38
	2	200	11.70	0.62	34
	3	300	18.00	0.21	82
	4	400	18.50	0.45	80
	5	500	19.70	0.39	98
	6	600	17.70	0.36	61
	7	700	21.00	0.20	75
	8	800	16.60	0.50	61
	9	900	15.50	0.51	98
	10	1000	21.35	0.48	23
	11	1100	17.00	0.54	56
	12	1200	12.50	0.77	68
	13	1300	14.80	0.72	85
	14	1420	17.20	0.64	56
	15	1520	17.50	0.50	98
	16	1600	16.80	0.76	29

Appendix B-1. Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Below Dam	2	1	1	R	100.0	11.83	C	60	G	40
Below Dam	4	1	1	GL	51.1	8.29	G	60	C	40
Below Dam	4	2	2	SP	7.5	5.00	C	50	S	50
Below Dam	4	3	2	R	17.0	5.20	C	70	G	30
Below Dam	4	4	1	R	48.4	9.48	C	70	G	30
Below Dam	4	5	2	BP	3.6	4.35	S	80	G	20
Below Dam	4	6	1	C	1.2	4.10	C	70	B	30
Below Dam	4	7	1	DP	1.5	5.30	C	80	G	20
Below Dam	6	1	1	R	30.8	10.52	C	80	G	20
Below Dam	6	2	1	GL	21.8	9.77	C	75	G	25
Below Dam	6	3	1	R	35.2	11.10	C	70	G	30
Below Dam	6	4	1	C	12.5	12.35	C	70	B	30
Below Dam	6	5	1	GL	17.0	11.37	C	60	G	40
Below Dam	8	1	1	GL	28.1	6.43	G	60	S	40
Below Dam	8	2	2	SP	20.0	2.92	S	65	G	35
Below Dam	8	3	1	R	67.7	9.96	C	80	G	20
Below Dam	8	4	2	SP	18.5	2.68	G	55	S	45
Below Dam	8	5	1	GL	1.5	7.15	G	70	C	30
Below Dam	10	1	1	GL	13.1	7.70	C	70	G	30
Below Dam	10	2	2	SP	4.0	1.10	G	70	BR	30
Below Dam	10	3	1	R	8.0	10.85	C	70	B	30
Below Dam	10	4	1	GL	19.3	7.90	G	70	C	30
Below Dam	10	5	2	SP	14.0	2.15	BR	70	C	30
Below Dam	10	6	1	C	13.1	7.85	C	50	B	50
Below Dam	10	7	1	GL	45.5	6.60	G	80	S	20
Below Dam	10	8	2	SP	10.0	4.25	G	80	S	20
Below Dam	12	1	1	T	7.0	6.15	G	90	C	10
Below Dam	12	2	2	T	5.5	5.50	S	90	G	10
Below Dam	12	3	1	SP	21.0	16.75	S	50	G	50
Below Dam	12	4	1	C	7.5	12.60	C	90	G	10
Below Dam	12	5	1	GL	24.3	7.73	C	70	G	30

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Below Dam	12	6	2	SP	12.3	4.03	SM	80	G	20
Below Dam	12	7	1	R	46.5	9.78	C	90	G	10
Below Dam	14	1	1	GL	30.0	9.40	C	60	G	40
Below Dam	14	2	2	SP	14.0	4.50	SM	50	G	50
Below Dam	14	3	2	SP	6.0	3.87	G	50	SM	50
Below Dam	14	4	1	R	11.0	12.40	C	70	G	30
Below Dam	14	5	1	C	6.0	4.30	C	50	G	50
Below Dam	14	6	1	DP	7.0	7.90	C	90	G	10
Below Dam	14	7	1	GL	42.5	9.22	C	80	G	20
Below Dam	14	8	2	SP	22.5	3.68	G	80	B	20
Below Dam	16	1	1	R	7.4	4.70	G	95	S	5
Below Dam	16	2	1	C	6.0	6.00	G	90	S	10
Below Dam	16	3	1	T	5.5	9.65	G	100		
Below Dam	16	4	1	SP	24.0	11.20	G	75	C	25
Below Dam	16	5	1	R	6.3	6.40	C	75	G	25
Below Dam	16	6	1	C	0.8	10.60	C	50	B	50
Below Dam	16	7	1	GL	29.0	11.60	G	80	C	20
Below Dam	16	8	1	R	14.7	5.40	G	60	C	40
Below Dam	16	9	2	P	14.0	3.40	BR	70	B	30
Below Dam	18	1	1	C	31.5	6.40	C	90	G	10
Below Dam	18	2	2	SP	9.5	2.85	S	50	BR	50
Below Dam	18	3	1	T	5.0	10.30	G	60	S	40
Below Dam	18	4	1	SP	57.5	10.63	S	70	G	30
Below Dam	18	5	1	C	3.5	8.30	BR	50	B	50
Below Dam	18	6	1	SP	4.0	7.60	BR	50	G	50
Below Dam	20	1	1	GL	28.3	8.70	G	90	S	10
Below Dam	20	2	2	GL	4.0	1.50	G	80	SM	20
Below Dam	20	3	2	SP	4.4	2.70	S	95	G	5
Below Dam	20	4	2	SP	17.9	2.55	S	90	G	10
Below Dam	20	5	1	SP	8.0	2.75	G	40	C	60
Below Dam	20	6	2	R	12.9	3.90	G	70	S	30

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Below Dam	20	7	1	C	10.3	25.70	G	40	C	60
Below Dam	20	8	1	GL	42.0	9.90	G	60	C	40
Below Dam	20	9	1	SP	9.6	11.40	S	80	G	20
Below Dam	22	1	1	C	5.5	11.20	G	60	C	40
Below Dam	22	2	1	GL	15.5	9.15	G	100		
Below Dam	22	3	2	SP	15.0	2.60	G	50	S	50
Below Dam	22	4	1	SP	22.2	9.80	G	90	S	10
Below Dam	22	5	1	R	33.5	7.47	G	90	C	10
Below Dam	22	6	2	SP	27.4	4.75	G	60	S	40
Below Dam	22	7	1	SP	18.4	10.05	S	50	G	50
Below Dam	24	1	1	SP	5.5	7.70	S	50	G	50
Below Dam	24	2	1	R	2.4	11.60	C	50	G	50
Below Dam	24	3	1	SP	22.0	13.70	S	80	SM	20
Below Dam	24	4	1	C	22.5	4.95	C	80	G	20
Below Dam	24	5	1	SP	28.0	10.15	G	95	S	5
Below Dam	24	6	1	SP	21.7	7.30	G	60	S	40
Below Dam	26	1	1	SP	18.0	7.67	C	50	G	50
Below Dam	26	2	1	R	19.3	8.50	C	60	G	40
Below Dam	26	3	1	SP	15.2	6.00	G	70	C	30
Below Dam	26	4	2	GL	9.3	3.60	G	60	C	40
Below Dam	26	5	1	C	25.1	6.50	C	70	G	30
Below Dam	26	6	1	R	22.3	10.40	G	80	S	20
Below Dam	28	1	1	TP	34.0	8.90	S	80	G	20
Below Dam	28	2	1	R	33.2	6.18	C	50	G	50
Below Dam	28	3	2	SP	12.0	3.47	S	60	G	40
Below Dam	28	4	1	C	21.0	6.17	C	90	G	10
Below Dam	28	5	2	SP	8.0	3.80	S	90	G	10
Below Dam	28	6	2	C	4.8	2.10	C	90	G	10
Below Dam	28	7	1	R	6.4	11.50	C	70	G	30
Below Dam	28	8	1	GL	4.6	11.00	G	50	S	50
Below Dam	30	1	1	R	48.5	6.98	C	90	G	10

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Below Dam	30	2	2	R	15.5	3.27	C	60	G	40
Below Dam	30	3	3	R	21.4	2.28	G	50	S	50
Below Dam	30	4	3	SP	20.0	3.23	G	65	S	35
Below Dam	30	5	3	R	2.4	2.10	G	65	S	35
Below Dam	30	6	3	SP	6.6	3.75	SM	90	G	10
Below Dam	30	7	3	R	7.0	1.35	G	50	S	50
Below Dam	30	8	3	SP	7.5	2.25	G	50	S	50
Below Dam	30	9	1	C	8.6	7.80	C	90	G	10
Below Dam	30	10	1	R	11.2	7.93	C	90	G	10
Below Dam	30	11	1	GL	32.2	10.30	C	70	S	30
Below Dam	30	12	1	R	2.5	12.40	C	90	G	10
Below Dam	32	1	1	SP	16.3	10.50	SM	50	S	50
Below Dam	32	2	1	R	32.0	8.18	G	50	S	50
Below Dam	32	3	2	SP	19.5	10.00	SM	80	S	20
Below Dam	32	4	2	R	23.0	4.90	G	70	C	30
Below Dam	32	5	2	R	4.1	2.60	G	90	C	10
Below Dam	32	6	2	R	12.8	4.05	G	70	C	30
Below Dam	32	7	1	SP	11.2	5.75	S	60	G	40
Below Dam	32	8	1	R	13.2	8.50	G	90	C	10
Below Dam	32	9	1	C	8.0	20.50	G	50	C	50
Below Dam	32	10	1	T	20.6	13.50	G	90	C	10
Below Dam	34	1	1	R	22.5	9.85	G	70	C	30
Below Dam	34	2	2	SP	28.5	4.90	G	60	BR	40
Below Dam	34	3	1	T	4.0	11.00	G	50	C	50
Below Dam	34	4	1	TP	32.5	9.50	BR	80	G	20
Below Dam	34	5	1	C	6.0	8.60	C	80	G	20
Below Dam	34	6	1	R	10.1	7.75	C	70	G	30
Below Dam	34	7	1	C	7.0	11.50	C	90	B	10
Below Dam	34	8	1	R	7.0	12.50	C	60	G	40
Below Dam	34	9	1	TP	7.5	11.00	C	90	B	10

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Above Dam	1	1	1	SP	19.6	11.30	S	80	G	20
Above Dam	1	2	1	R	15.3	12.05	G	50	C	50
Above Dam	1	3	2	SP	10.9	10.90	S	60	G	40
Above Dam	1	4	1	T	4.5	8.90	G	80	C	20
Above Dam	1	5	1	SP	14.6	8.87	S	50	G	50
Above Dam	1	6	1	R	2.5	11.30	G	100		
Above Dam	1	7	1	SP	12.7	9.85	S	90	G	10
Above Dam	1	8	1	C	2.4	12.00	G	50	C	50
Above Dam	1	9	2	C	17.0	8.20	G	70	S	30
Above Dam	1	10	3	SP	19.0	4.72	SM	100		
Above Dam	1	11	1	SP	25.9	5.88	G	70	S	30
Above Dam	1	12	2	GL	15.0	4.87	S	90	G	10
Above Dam	1	13	1	T	3.3	7.60	G	50	C	50
Above Dam	1	14	1	SP	9.3	10.45	SM	60	G	40
Above Dam	3	1	1	C	6.0	7.60	G	70	C	30
Above Dam	3	2	1	T	5.9	9.10	G	95	C	5
Above Dam	3	3	1	SP	22.9	7.50	G	70	S	30
Above Dam	3	4	1	T	5.6	9.70	G	50	C	50
Above Dam	3	5	1	SP	25.1	6.88	G	80	S	20
Above Dam	3	6	2	R	3.0	2.40	G	60	C	40
Above Dam	3	7	2	SP	13.0	3.00	S	80	G	20
Above Dam	3	8	1	T	3.8	9.50	G	80	C	20
Above Dam	3	9	1	SP	28.3	8.30	G	90	S	10
Above Dam	3	10	1	R	9.8	4.97	G	50	C	50
Above Dam	3	11	2	SP	7.5	5.65	G	50	C	50
Above Dam	3	12	1	C	6.0	3.20	S	80	G	20
Above Dam	5	1	1	R	19.0	9.67	G	80	C	20
Above Dam	5	2	2	SP	17.0	2.07	SM	90	G	10
Above Dam	5	3	1	SP	44.2	7.54	G	90	S	10
Above Dam	5	4	2	GL	15.0	7.83	G	60	S	40
Above Dam	5	5	1	R	34.7	12.80	C	50	G	50

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Above Dam	5	6	1	T	4.0	9.10	G	95	C	5
Above Dam	5	7	1	SP	9.4	9.75	G	100		
Above Dam	5	8	2	SP	9.3	4.35	G	50	S	50
Above Dam	7	1	1	R	22.4	0.62	C	70	G	30
Above Dam	7	2	2	SP	19.4	0.41	C	70	S	30
Above Dam	7	3	1	T	6.0	0.93	C	70	G	30
Above Dam	7	4	1	SP	75.8	4.40	S	60	G	40
Above Dam	7	5	2	GL	67.8	4.49	S	70	C	30
Above Dam	7	6	1	R	8.0	6.20	C	70	S	30
Above Dam	9	1	1	SP	11.5	7.83	S	90	G	10
Above Dam	9	2	1	C	4.0	17.50	G	80	C	20
Above Dam	9	3	1	T	5.5	7.40	S	70	G	30
Above Dam	9	4	1	SP	22.8	7.73	S	90	G	10
Above Dam	9	5	1	R	9.7	8.20	G	80	C	20
Above Dam	9	6	1	T	8.1	8.30	G	50	S	50
Above Dam	9	7	1	SP	19.6	5.57	G	80	S	20
Above Dam	9	8	2	GL	12.0	2.95	G	50	C	50
Above Dam	9	9	1	R	29.4	4.18	C	60	G	40
Above Dam	9	10	2	C	7.0	5.75	C	70	G	30
Above Dam	9	11	2	SP	12.1	5.47	C	70	G	30
Above Dam	9	12	2	C	6.0	2.70	C	70	G	30
Above Dam	9	13	2	T	3.2	6.10	C	90	G	10
Above Dam	9	14	1	SP	2.5	5.30	C	90	G	10
Above Dam	9	15	2	SP	4.0	3.00	S	95	G	5
Above Dam	9	16	1	C	5.3	5.10	C	75	G	25
Above Dam	11	1	1	SP	100.0	12.73	S	95	C	5
Above Dam	14	1	1	R	21.5	8.60	C	50	G	50
Above Dam	14	2	1	T	5.2	10.80	G	80	C	20
Above Dam	14	3	1	SP	14.4	8.85	S	60	G	40
Above Dam	14	4	1	R	4.6	12.10	C	90	G	10
Above Dam	14	5	1	T	3.5	7.80	C	60	G	40

Appendix B-1 (cont.). Goldsborough Creek instream habitat survey data [1].

Segment	Reference Point	Habitat Unit					Dominant Substrate		Sub-dominant Substrate	
		Number	Category	Type	Length (m)	Width (m)	Code	(%)	Code	(%)
Above Dam	14	6	1	SP	16.7	6.63	S	80	G	20
Above Dam	14	7	1	C	16.2	10.67	C	90	G	10
Above Dam	14	8	1	R	28.3	10.13	C	80	S	20
Above Dam	15	1	1	R	21.1	8.73	C	80	S	20
Above Dam	15	2	1	T	10.0	13.50	C	80	S	20
Above Dam	15	3	1	SP	48.9	8.28	S	85	C	15
Above Dam	15	4	2	PP	7.5	4.55	S	95	G	5
Above Dam	15	5	2	GL	12.4	5.57	S	95	G	5
Above Dam	15	6	2	SP	10.0	4.45	SM	100		

[1] Instream habitat survey codes:

Unit Category:
1 = > 50% of the wetted channel width
2 = < 50% of the wetted channel width
3 = Side channel; isolated by island or established gravel bar

Substrate:
SM = Silt/mud
S = Sand
G = Gravel
C = Cobble
B = Bolder
BR = Bedrock

Unit:
SP = Scour pool
PP = Plunge pool
DP = Dammed pool
TP = Trench pool
BP = Backwater pool
T = Tailout
GL = Glide
R = Riffle
C = Cascade

Appendix B-2. Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Below Dam	2	1	4	M	5	7	9	M	5	7
Below Dam	4	1	4	D	5	7	4	M	5	20
Below Dam	4	2	4	D	5	7	4	D	5	5
Below Dam	4	3	4	D	5	7	4	D	5	5
Below Dam	4	4	4	D	5	7	4	D	5	7
Below Dam	4	5	4	D	5	7	4	D	5	7
Below Dam	4	6	4	D	5	7	4	D	5	7
Below Dam	4	7	4	D	5	15	4	D	5	7
Below Dam	6	1	4	D	5	5	4	D	5	5
Below Dam	6	2	4	D	5	2	4	D	5	5
Below Dam	6	3	4	M	5	10	4	D	5	2
Below Dam	6	4	4	D	5	5	4	D	5	10
Below Dam	6	5	4	D	5	2	4	D	5	5
Below Dam	8	1	4	D	5	2	4	D	5	10
Below Dam	8	2	4	D	5	2	4	D	5	10
Below Dam	8	3	4	D	5	25	4	D	5	30
Below Dam	8	4	4	D	5	25	4	D	5	30
Below Dam	8	5	4	D	5	25	4	D	5	30
Below Dam	10	1	4	D	5	10	3	M	5	30
Below Dam	10	2	4	D	5	10	3	M	5	30
Below Dam	10	3	4	D	5	10	3	M	5	30
Below Dam	10	4	4	D	5	10	3	M	5	30
Below Dam	10	5	4	D	5	10	3	M	5	30
Below Dam	10	6	4	D	5	10	3	M	5	30
Below Dam	10	7	4	D	5	10	3	M	5	30
Below Dam	10	8	4	D	5	10	3	M	5	30
Below Dam	12	1	4	D	5	10	3	M	5	30
Below Dam	12	2	4	D	5	10	3	M	5	30
Below Dam	12	3	4	D	5	10	3	M	5	30
Below Dam	12	4	4	D	5	10	3	M	5	30
Below Dam	12	5	4	D	5	10	4	D	5	3
Below Dam	12	6	4	D	5	10	4	D	5	3
Below Dam	12	7	4	D	1-	5	4	M	5	15
Below Dam	14	1	4	D	5	10	4	D	5	3
Below Dam	14	2	4	D	5	10	4	D	5	3
Below Dam	14	3	4	D	5	10	4	D	5	3
Below Dam	14	4	4	D	5	5	4	M	5	15
Below Dam	14	5	4	D	5	10	4	D	4	10

Appendix B-2 (cont.). Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Below Dam	14	6	4	D	5	10	4	D	4	10
Below Dam	14	7	4	M	5	15	4	D	3	15
Below Dam	14	8	4	M	5	15	4	D	3	15
Below Dam	16	1	4	D	5	30	4	D	5	15
Below Dam	16	2	4	D	5	30	4	D	5	15
Below Dam	16	3	4	D	5	30	4	D	5	15
Below Dam	16	4	4	D	5	30	3	D	5	15
Below Dam	16	5	4	D	5	30	3	D	5	30
Below Dam	16	6	4	D	5	30	3	D	5	30
Below Dam	16	7	4	D	5	30	3	D	5	30
Below Dam	16	8	4	D	5	30	3	M	5	30
Below Dam	16	9	4	D	5	30	3	M	5	30
Below Dam	18	1	4	D	5	15	3	M	5	30
Below Dam	18	2	4	D	5	15	3	M	5	30
Below Dam	18	3	4	D	5	15	3	M	5	30
Below Dam	18	4	4	D	5	10	3	M	5	30
Below Dam	18	5	4	D	5	20	3	D	4	30
Below Dam	18	6	4	D	5	20	3	D	4	30
Below Dam	20	1	4	D	5	25	3	M	5	30
Below Dam	20	2	4	D	5	25	3	M	5	30
Below Dam	20	3	4	D	5	25	3	M	5	30
Below Dam	20	4	4	D	5	25	3	M	5	30
Below Dam	20	5	4	M	5	20	3	M	5	30
Below Dam	20	6	4	M	5	20	3	M	5	30
Below Dam	20	7	4	M	5	20	3	M	5	30
Below Dam	20	8	4	D	5	20	3	D	4	30
Below Dam	20	9	4	D	5	5	3	D	4	30
Below Dam	22	1	4	D	5	10	3	M	5	30
Below Dam	22	2	4	D	5	10	3	M	5	30
Below Dam	22	3	4	D	5	10	3	M	5	30
Below Dam	22	4	4	D	5	5	3	M	5	30
Below Dam	22	5	4	D	5	15	3	M	5	30
Below Dam	22	6	4	D	5	15	3	D	5	30
Below Dam	22	7	4	D	5	15	3	D	5	30
Below Dam	24	1	4	D	5	25	0	D	5	30
Below Dam	24	2	4	D	5	25	0	D	5	30
Below Dam	24	3	4	D	5	30	0	D	5	30
Below Dam	24	4	4	D	5	30	0	D	5	30

Appendix B-2 (cont.). Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Below Dam	24	5	4	D	5	30	0	D	5	30
Below Dam	24	6	4	D	5	30	5	D	4	10
Below Dam	26	1	1	D	1	15	5	D	4	20
Below Dam	26	2	1	D	5	30	5	D	4	20
Below Dam	26	3	1	D	5	30	5	D	4	20
Below Dam	26	4	1	D	5	30	5	D	4	20
Below Dam	26	5	5	D	4	30	5	D	4	10
Below Dam	26	6	5	D	5	30	5	D	4	10
Below Dam	28	1	0	D	5	30	0	D	4	30
Below Dam	28	2	0	M	5	30	0	M	5	30
Below Dam	28	3	0	M	5	30	0	M	5	30
Below Dam	28	4	0	M	5	30	0	D	4	30
Below Dam	28	5	0	M	5	30	0	D	4	30
Below Dam	28	6	0	M	5	30	0	D	4	30
Below Dam	28	7	0	M	5	30	0	D	4	30
Below Dam	28	8	0	M	5	30	0	D	4	30
Below Dam	30	1	5	D	5	30	5	D	1	30
Below Dam	30	2	5	D	5	30	5	D	1	30
Below Dam	30	3	5	D	5	30	5	D	1	30
Below Dam	30	4	5	D	5	30	5	D	1	30
Below Dam	30	5	5	D	5	30	5	D	1	30
Below Dam	30	6	0	M	5	30	3	M	5	30
Below Dam	30	7	0	M	5	30	3	M	5	30
Below Dam	30	8	0	M	5	30	3	M	5	30
Below Dam	30	9	0	M	5	30	3	M	5	30
Below Dam	30	10	0	M	5	30	3	M	5	30
Below Dam	30	11	0	M	5	30	3	M	5	30
Below Dam	30	12	0	M	5	30	3	M	5	30
Below Dam	32	1	5	M	5	15	3	M	5	30
Below Dam	32	2	5	M	5	15	3	M	5	30
Below Dam	32	3	5	M	5	15	3	M	5	30
Below Dam	32	4	5	M	5	15	3	M	5	30
Below Dam	32	5	5	M	5	15	3	M	5	30
Below Dam	32	6	5	M	5	15	3	M	5	30
Below Dam	32	7	5	M	5	15	3	M	5	30
Below Dam	32	8	5	M	5	15	3	M	5	30
Below Dam	32	9	5	M	5	15	3	M	5	30
Below Dam	32	10	5	M	5	15	3	M	5	30

Appendix B-2 (cont.). Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Below Dam	34	1	5	M	5	30	3	M	5	30
Below Dam	34	2	5	M	5	30	3	M	5	30
Below Dam	34	3	5	M	5	30	3	M	5	30
Below Dam	34	4	5	M	5	30	3	M	5	30
Below Dam	34	5	5	M	5	15	3	M	5	30
Below Dam	34	6	5	M	5	15	3	M	5	30
Below Dam	34	7	5	M	5	15	3	M	5	30
Below Dam	34	8	5	M	5	15	3	M	5	30
Below Dam	34	9	5	M	5	15	3	M	5	30
Above Dam	1	1	0	D	5	30	3	M	5	30
Above Dam	1	2	0	D	5	30	3	M	5	30
Above Dam	1	3	0	D	5	30	3	D	5	30
Above Dam	1	4	0	D	5	30	3	D	5	30
Above Dam	1	5	0	D	5	30	3	D	5	30
Above Dam	1	6	0	D	5	30	3	D	5	30
Above Dam	1	7	0	D	5	30	3	D	5	30
Above Dam	1	8	0	D	5	30	3	D	5	30
Above Dam	1	9	0	D	5	30	3	D	5	30
Above Dam	1	10	0	D	5	30	3	D	5	30
Above Dam	1	11	0	D	5	30	3	D	5	30
Above Dam	1	12	0	M	5	30	3	D	5	30
Above Dam	1	13	0	M	5	30	3	D	4	30
Above Dam	1	14	0	M	5	30	3	D	4	30
Above Dam	3	1	3	M	5	30	3	M	5	30
Above Dam	3	2	3	M	5	30	3	D	5	30
Above Dam	3	3	3	M	5	30	3	D	5	30
Above Dam	3	4	3	M	5	30	3	D	5	30
Above Dam	3	5	3	M	5	30	3	D	5	30
Above Dam	3	6	3	M	5	30	3	D	5	30
Above Dam	3	7	3	M	5	30	3	D	5	30
Above Dam	3	8	3	M	5	30	3	M	5	30
Above Dam	3	9	3	M	5	30	3	M	5	30
Above Dam	3	10	3	M	5	30	3	M	5	30
Above Dam	3	11	3	M	5	30	3	M	5	30
Above Dam	3	12	3	M	5	30	3	M	5	30
Above Dam	5	1	3	D	5	30	3	M	5	30
Above Dam	5	2	3	D	5	30	3	M	5	30
Above Dam	5	3	3	D	5	30	3	M	5	30

Appendix B-2 (cont.). Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Above Dam	5	4	3	D	5	30	3	M	5	30
Above Dam	5	5	3	M	5	30	3	M	5	30
Above Dam	5	6	3	M	5	30	3	M	5	30
Above Dam	5	7	3	M	5	30	3	M	5	30
Above Dam	5	8	3	M	5	30	3	M	5	30
Above Dam	7	1	3	M	5	30	3	M	5	30
Above Dam	7	2	3	M	5	30	3	M	5	30
Above Dam	7	3	3	M	5	30	3	M	5	30
Above Dam	7	4	3	M	5	30	3	M	5	30
Above Dam	7	5	3	M	5	30	3	M	5	30
Above Dam	7	6	3	M	5	30	3	M	5	30
Above Dam	9	1	3	M	5	30	3	M	5	30
Above Dam	9	2	3	M	5	30	3	M	5	30
Above Dam	9	3	3	M	5	30	3	M	5	30
Above Dam	9	4	3	M	5	30	3	M	5	30
Above Dam	9	5	3	M	5	30	3	M	5	30
Above Dam	9	6	3	M	5	30	3	D	5	30
Above Dam	9	7	3	M	5	30	3	M	5	30
Above Dam	9	8	3	M	5	30	3	M	5	30
Above Dam	9	9	3	M	5	30	3	M	5	30
Above Dam	9	10	3	M	5	30	3	M	5	30
Above Dam	9	11	3	M	5	30	3	M	5	30
Above Dam	9	12	3	M	5	30	3	M	5	30
Above Dam	9	13	3	M	5	30	3	M	5	30
Above Dam	9	14	3	M	5	30	3	M	5	30
Above Dam	9	15	3	M	5	30	3	M	5	30
Above Dam	9	16	3	M	5	30	3	M	5	30
Above Dam	11	1	3	M	5	30	3	M	5	30
Above Dam	14	1	3	M	5	30	3	M	5	30
Above Dam	14	2	3	M	5	30	3	M	5	30
Above Dam	14	3	3	M	5	30	3	M	5	30
Above Dam	14	4	3	M	5	30	3	M	5	30
Above Dam	14	5	3	M	5	30	3	M	5	30
Above Dam	14	6	3	M	5	30	3	M	5	30
Above Dam	14	7	3	M	5	30	3	M	5	30
Above Dam	14	8	3	M	5	30	3	M	5	30
Above Dam	15	1	3	M	5	30	3	M	5	30
Above Dam	15	2	3	M	5	30	3	M	5	30

Appendix B-2 (cont.). Goldsborough Creek land use and streambank habitat survey data, September, 1998 [1].

Segment	Reference Point	Unit Number	Left bank				Right bank			
				Vegetation				Vegetation		
			Land use	Type	Stage	Distance	Land use	Type	Stage	Distance
Above Dam	15	3	3	M	5	30	3	M	5	30
Above Dam	15	4	3	M	5	30	3	M	5	30
Above Dam	15	5	3	M	5	30	3	M	5	30
Above Dam	15	6	3	M	5	30	3	M	5	30

[1] Streamside habitat monitoring survey codes

Land Use:
0 = Private woodlot
1 = Agricultural
2 = Livestock grazing/pasture
3 = Timber lands
4 = Residential
5 = Right of way (I.e., roads)
9 = Other (park)

Vegetation Type:
C = Coniferous
D = Deciduous
M = Mixed

Stage:
0 = No vegetation
1= Grass/forbe
2 = Shrub/seedling
3 = Pole/sapling
4 = Young
5 = Mature timber
6 = Old growth

Distance:
Distance of vegetation from wetted edge in meters, up to a maximum of 30 meters.

Appendix C-1. Woody debris, excluding log jams, recorded in lower Goldsborough Creek, September-October, 1998 [1].

Segment	Reference Point	Unit Number	Zone	Wood Count			
				Rootwads	Small	Medium	Large
Below Dam	2	1	1	4	0	2	0
Below Dam	4	1	1	1	2	0	0
Below Dam	4	1	2	2	4	0	0
Below Dam	4	1	3	3	0	1	0
Below Dam	4	3	1	0	2	0	0
Below Dam	4	4	1	1	2	0	0
Below Dam	6	1	1	0	1	0	0
Below Dam	6	1	2	0	0	1	0
Below Dam	6	2	1	1	4	2	0
Below Dam	6	2	2	1	0	0	0
Below Dam	8	4	1	0	0	1	0
Below Dam	10	1	1	0	2	1	0
Below Dam	10	4	2	1	0	3	0
Below Dam	10	4	3	0	0	3	1
Below Dam	10	7	1	0	1	1	0
Below Dam	10	7	3	0	0	0	1
Below Dam	10	8	1	1	1	0	1
Below Dam	12	1	1	0	1	0	0
Below Dam	12	2	1	0	1	0	0
Below Dam	12	2	2	0	0	1	0
Below Dam	12	3	1	0	2	0	0
Below Dam	12	3	3	0	0	2	0
Below Dam	12	4	2	0	1	0	0
Below Dam	12	7	1	0	1	0	0
Below Dam	12	7	2	0	1	0	0
Below Dam	14	7	1	0	2	4	1
Below Dam	14	7	3	0	2	0	0
Below Dam	16	2	1	0	3	0	0
Below Dam	16	3	1	1	4	5	0
Below Dam	16	3	3	0	1	1	0
Below Dam	16	4	1	1	1	1	0
Below Dam	16	5	1	0	1	0	0
Below Dam	16	7	1	0	5	2	0
Below Dam	16	7	2	0	2	0	0
Below Dam	16	8	1	0	1	1	0
Below Dam	16	9	1	0	1	0	0
Below Dam	16	9	2	0	2	1	0
Below Dam	18	1	2	0	2	0	0
Below Dam	18	4	1	0	2	0	0
Below Dam	18	5	1	0	0	1	0
Below Dam	20	1	3	0	0	3	0
Below Dam	20	6	1	0	1	1	0
Below Dam	20	7	1	0	2	0	0
Below Dam	20	8	1	0	1	1	0
Below Dam	20	8	2	0	1	3	0
Below Dam	22	1	1	0	2	0	0
Below Dam	22	1	2	0	0	1	0
Below Dam	22	2	3	0	0	1	0
Below Dam	22	3	1	3	0	0	0
Below Dam	22	4	1	0	1	2	0
Below Dam	22	7	1	0	2	0	0
Below Dam	22	7	3	0	0	1	0
Below Dam	24	3	1	0	3	0	0
Below Dam	24	3	2	0	5	1	0
Below Dam	24	4	1	1	0	0	0
Below Dam	24	4	2	0	2	1	0

Appendix C-1 (cont.). Woody debris, excluding log jams, recorded in lower Goldsborough Creek, September-October, 1998 [1].

Segment	Reference Point	Unit Number	Zone	Wood Count			
				Rootwads	Small	Medium	Large
Below Dam	24	4	3	0	0	2	0
Below Dam	24	5	1	4	14	1	0
Below Dam	24	5	2	0	2	0	0
Below Dam	24	6	1	1	5	3	0
Below Dam	26	1	1	0	4	3	0
Below Dam	26	1	2	0	4	2	0
Below Dam	26	1	3	0	3	1	0
Below Dam	26	2	1	1	1	0	0
Below Dam	26	2	2	0	2	0	0
Below Dam	26	2	3	0	1	0	0
Below Dam	26	5	1	0	5	2	0
Below Dam	26	5	3	0	1	1	0
Below Dam	28	1	1	0	2	0	0
Below Dam	28	1	2	0	2	0	0
Below Dam	28	2	1	0	2	4	0
Below Dam	28	2	2	0	1	0	0
Below Dam	28	4	1	0	0	1	0
Below Dam	30	1	2	0	0	0	1
Below Dam	30	3	1	0	1	0	1
Below Dam	30	3	2	0	0	2	0
Below Dam	30	4	1	1	3	0	0
Below Dam	30	4	2	0	0	1	0
Below Dam	30	4	3	0	1	0	0
Below Dam	30	6	1	0	2	1	0
Below Dam	30	11	1	0	2	1	0
Below Dam	30	11	3	0	1	0	0
Below Dam	32	2	1	1	0	0	0
Below Dam	32	8	1	0	1	1	0
Below Dam	32	9	1	1	0	1	0
Below Dam	32	9	2	0	0	2	0
Below Dam	32	10	1	0	4	0	0
Below Dam	32	10	2	0	0	2	0
Below Dam	34	1	1	0	0	1	0
Below Dam	34	2	1	0	1	1	0
Below Dam	34	2	2	0	1	1	0
Below Dam	34	3	1	0	2	1	0
Below Dam	34	8	1	0	2	1	0
Below Dam	34	9	1	0	0	1	0
Above Dam	1	1	1	0	18	7	2
Above Dam	1	1	2	0	1	1	0
Above Dam	1	1	3	0	2	0	0
Above Dam	1	2	1	0	1	2	1
Above Dam	1	3	1	1	5	3	0
Above Dam	1	3	2	0	2	0	0
Above Dam	1	3	3	0	2	1	0
Above Dam	1	5	1	1	5	4	0
Above Dam	1	5	2	0	2	0	0
Above Dam	1	7	1	2	0	1	0
Above Dam	1	7	2	0	1	0	1
Above Dam	1	8	1	0	1	0	0
Above Dam	1	10	1	0	7	5	0
Above Dam	1	10	2	0	2	3	0
Above Dam	1	11	1	1	10	6	0
Above Dam	1	11	2	0	1	0	0
Above Dam	1	12	2	0	1	1	0
Above Dam	1	13	1	0	1	0	0

Appendix C-1 (cont.). Woody debris, excluding log jams, recorded in lower Goldsborough Creek, September-October, 1998 [1].

Segment	Reference Point	Unit Number	Zone	Wood Count			
				Rootwads	Small	Medium	Large
Above Dam	1	14	1	0	5	2	0
Above Dam	1	14	3	0	0	1	0
Above Dam	1	15	1	0	0	2	0
Above Dam	1	15	2	0	1	2	0
Above Dam	1	15	3	0	3	1	0
Above Dam	1	16	1	0	1	2	0
Above Dam	1	17	1	0	0	1	0
Above Dam	1	17	2	0	2	0	0
Above Dam	3	1	1	0	0	1	0
Above Dam	3	1	2	0	0	0	1
Above Dam	3	1	3	0	0	1	0
Above Dam	3	3	1	0	3	1	0
Above Dam	3	4	1	0	1	1	0
Above Dam	3	5	1	0	2	0	0
Above Dam	3	5	3	0	0	0	1
Above Dam	3	8	1	0	1	0	0
Above Dam	3	9	1	0	7	1	0
Above Dam	3	9	3	0	2	1	0
Above Dam	3	10	2	0	1	0	0
Above Dam	3	11	1	0	1	1	0
Above Dam	3	12	1	0	0	1	0
Above Dam	3	12	2	0	1	1	0
Above Dam	5	1	1	0	1	3	0
Above Dam	5	1	2	0	1	1	0
Above Dam	5	1	3	0	1	0	0
Above Dam	5	2	1	0	3	1	1
Above Dam	5	2	2	0	6	0	0
Above Dam	5	2	3	0	1	1	0
Above Dam	5	3	1	0	4	0	0
Above Dam	5	3	2	0	2	1	0
Above Dam	5	4	1	0	2	0	0
Above Dam	5	4	2	0	0	1	0
Above Dam	5	5	1	0	4	1	0
Above Dam	5	5	2	0	1	0	0
Above Dam	5	7	1	0	1	0	0
Above Dam	5	7	2	0	0	2	0
Above Dam	5	7	3	0	0	1	0
Above Dam	5	8	1	0	1	0	0
Above Dam	7	1	1	0	1	0	0
Above Dam	7	2	2	0	1	1	0
Above Dam	7	2	3	0	0	2	0
Above Dam	7	3	1	0	1	0	0
Above Dam	7	4	1	1	2	1	1
Above Dam	7	5	1	0	1	0	0
Above Dam	7	5	2	0	1	0	0
Above Dam	7	6	2	0	2	0	0
Above Dam	9	1	2	0	0	0	1
Above Dam	9	3	1	0	1	0	0
Above Dam	9	4	1	1	7	2	1
Above Dam	9	4	2	0	0	1	0
Above Dam	9	5	1	0	3	2	0
Above Dam	9	5	2	0	6	5	2
Above Dam	9	6	1	0	1	0	0
Above Dam	9	7	1	0	0	4	0
Above Dam	9	8	1	0	0	2	0
Above Dam	9	9	1	0	1	2	1

Appendix C-1 (cont.). Woody debris, excluding log jams, recorded in lower Goldsborough Creek, September-October, 1998 [1].

Segment	Reference Point	Unit Number	Zone	Wood Count			
				Rootwads	Small	Medium	Large
Above Dam	9	9	2	0	0	2	0
Above Dam	9	9	3	0	0	1	0
Above Dam	9	10	1	0	1	2	0
Above Dam	9	10	2	0	0	1	0
Above Dam	9	10	3	0	1	1	0
Above Dam	9	11	1	0	1	1	0
Above Dam	9	11	2	0	0	1	0
Above Dam	11	1	1	5	4	5	1
Above Dam	11	1	2	0	2	1	1
Above Dam	11	1	3	0	1	4	0
Above Dam	14	1	1	0	2	2	1
Above Dam	14	1	2	0	2	2	1
Above Dam	14	1	3	0	2	0	0
Above Dam	14	2	1	0	1	0	0
Above Dam	14	3	1	0	1	1	2
Above Dam	14	3	3	0	1	0	0
Above Dam	14	4	1	1	0	2	0
Above Dam	14	6	1	0	4	1	1
Above Dam	14	6	2	0	2	3	0
Above Dam	14	7	1	0	2	0	2
Above Dam	14	7	2	0	2	0	0
Above Dam	14	8	1	0	3	2	1
Above Dam	15	1	2	0	0	0	1
Above Dam	15	2	1	0	1	1	0
Above Dam	15	2	2	0	0	2	0
Above Dam	15	3	1	1	2	3	1
Above Dam	15	3	2	0	3	3	0
Above Dam	15	3	3	0	1	0	0
Above Dam	15	4	1	0	1	1	0
Above Dam	15	5	2	0	0	1	0
Above Dam	15	6	1	0	1	1	0
Above Dam	15	6	2	0	0	1	0

[1] Woody Debris Survey Codes:

Zones:
1 = Within the wetted width
2 = Within the bankfull channel
3 = Above the bankfull channel

Wood Categories:
Rootwad = 20 cm or greater at base of stem
Small = 10-20 cm diameter at midpoint
Medium = 20-50 cm diameter at midpoint
Large = Greater than 50 cm diameter at midpoint

Appendix C-2. Log jams recorded in lower Goldsborough Creek September-October, 1998.

Segment	Reference Point	Unit Number	Jam					Wood Count [1]			
			Number	Zone	Width (m)	Length (m)	Height (m)	Rootwads	Small	Medium	Large
Below Dam	4	6	1	1	0.6	10.0	0.4	1	6	4	0
	12	3	1	1	3.0	4.5	1.5	1	4	2	1
	12	3	2	1	20.0	6.0	1.8	6	34	16	3
	14	2	1	1	5.2	13.0	1.6	1	4	3	0
	18	4	1	1	8.0	10.0	1.5	0	6	3	2
	18	4	2	1	3.0	14.0	2.0	3	5	1	1
	20	9	1	1	3.0	10.0	1.0	0	5	3	0
	24	1	1	1	6.0	17.0	3.0	3	13	13	1
	24	3	1	1	7.0	15.0	1.5	8	11	4	1
	26	1	1	1	4.0	15.0	2.3	2	17	10	1
	26	3	1	1	3.5	18.2	1.5	1	1	6	0
	28	1	1	1	4.0	7.0	2.2	1	8	6	0
	28	2	1	1	5.0	17.5	2.3	4	23	11	2
	28	2	2	1	5.5	15.0	1.5	0	10	8	0
	30	3	1	1	3.5	12.0	1.5	0	9	1	0
	30	9	1	1	7.0	11.5	2.6	1	14	5	0
	30	11	1	1	4.5	16.0	1.5	0	7	4	0
	32	3	1	1	15.0	14.0	4.5	0	10	6	3
	32	7	1	1	7.0	20.0	2.2	0	7	4	0
Above Dam	1	6	1	1	30.0	20.0	1.5	0	17	15	0
	3	9	1	1	4.0	1.5	1.7	0	5	5	0
	9	1	1	1	6.0	4.5	1.5	1	9	6	1

[1] Woody Debris Categories:

Rootwads = 20 cm or greater at base of stem
Small logs = 10-20 cm diameter at midpoint
Medium logs = 20-50 cm diameter at midpoint
Large logs = Greater than 50 cm diameter at midpoint

Appendix D. Cutbanks and mass wastings recorded in lower Goldsborough Creek, Sept. - Oct., 1998 [1].

			Left Bank				Right Bank			
	Reference	Unit	Cutbanks		Mass Wastings		Cutbanks		Mass Wastings	
Segment	Point	Number	Length	Height	Length	Height	Length	Height	Length	Height
Below Dam	2	1	22.0	0.3			40.0	0.4	2.0	3.0
Below Dam	4	1	12.0	0.4			15.0	0.3		
Below Dam	4	2					7.5	0.4		
Below Dam	4	3					13.0	0.4	4.0	5.0
Below Dam	4	4	5.0	0.6			10.0	0.4	3.0	4.0
Below Dam	4	5	3.6	0.3						
Below Dam	6	2					10.0	0.3		
Below Dam	6	3			2.0	4.0	4.0	0.5		
Below Dam	8	4					67.7	0.4		
Below Dam	10	2	3.0	0.5						
Below Dam	10	3	8.0	2.0						
Below Dam	10	7					20.0	0.4		
Below Dam	12	2					5.5	0.5		
Below Dam	12	4					7.5	0.8		
Below Dam	12	5	9.0	0.4			10.0	0.8		
Below Dam	14	7							5.0	4.0
Below Dam	16	1	10.0	0.4						
Below Dam	16	4					20.0	10.0		
Below Dam	16	7					10.0	9.0		
Below Dam	18	1							22.0	10.0
Below Dam	18	3							5.0	10.0
Below Dam	18	4							15.0	4.0
Below Dam	22	1			5.5	3.0				
Below Dam	22	2			15.5	3.0				
Below Dam	22	4							20.0	10.0
Below Dam	24	3							20.0	5.0
Below Dam	24	4							20.0	5.0
Below Dam	24	6							20.0	5.0
Below Dam	26	1			15.0	15.0				
Below Dam	26	2					15.0	0.3		
Below Dam	28	1							20.0	8.0
Below Dam	28	2							25.0	15.0
Below Dam	28	4							15.0	5.0
Below Dam	28	7							8.0	5.0
Below Dam	30	3	10.0	0.5						
Below Dam	30	9							8.6	5.5
Below Dam	30	10							11.2	5.5

Appendix D (cont.). Cutbanks and mass wastings recorded in lower Goldsborough Creek, Sept. - Oct., 1998 [1].

Segment	Reference Point	Unit Number	Left Bank				Right Bank			
			Cutbanks		Mass Wastings		Cutbanks		Mass Wastings	
			Length	Height	Length	Height	Length	Height	Length	Height
Below Dam	30	11							32.2	5.5
Below Dam	32	3					17.5	5.0		
Below Dam	32	6					12.8	5.0		
Below Dam	32	9					8.0	5.0		
Below Dam	32	10					30.0	5.0		
Above Dam	1	7	4.0	0.5	11.5	6.0				
Above Dam	3	9			4.0	15.0				
Above Dam	3	10			4.0	15.0				
Above Dam	3	11	1.0	0.4						
Above Dam	11	1	3.0	0.2						
Above Dam	14	2	5.0	0.4						

[1] All measurements in meters.

Chinook, Coho, and Chum Salmon Spawner Escapement Estimates -1998

Brian R. Missildine, Roger J. Peters, David L. Low

Introduction

Washington Department of Fish and Wildlife (WDFW) currently has three index reaches in the Goldsborough watershed. The chum salmon index is from RKm 0.8-3.5 in Goldsborough Creek and RKm 0.0-0.5 in Coffee Creek. The coho salmon index, which has been surveyed since 1978, is in RKm 16-17.7 in the South Fork Goldsborough Creek. As there currently is no chinook salmon index reach for Goldsborough Creek, the relative abundance of adult chinook salmon is unknown.

The objectives of the spawner surveys are: 1) determine pre-dam removal abundance and distribution above and below the dam, and 2) determine the possible impact of the restoration project on current spawning grounds. Post-project surveys will help determine fish usage and fish passage through the restored reach.

Study Area

Goldsborough Creek is located in Mason County, Washington, and flows through the town of Shelton (Figure 1). The watershed drains approximately 140 km^2 and includes several palustrine forested, scrub/shrub, emergent, and open water wetlands, and several small lakes (Parametrix 1998). Land-use in the lower reach of the creek is heavily urbanized, while the upper watershed is primarily forested with sparse residential areas (Fraser 1993). The stream channel below the dam has experienced severe degradation. The channel has become incised and in some locations is scoured down to bedrock. Surveys indicate the stream reach above the dam is aggrading (Sylwester 1996).

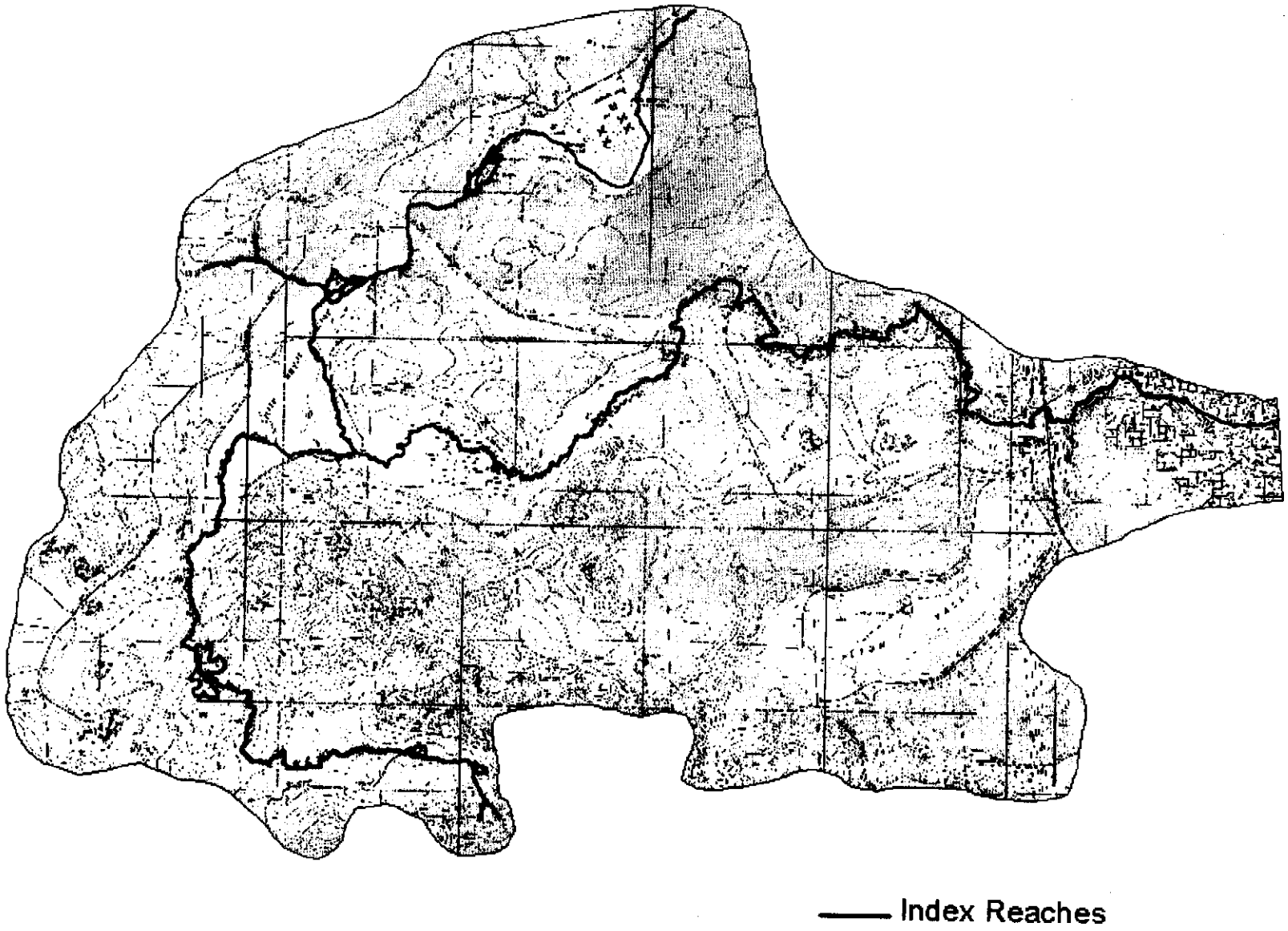

Figure 1. Salmonid spawner indices surveyed in the Goldsborough Creek watershed.

Methods

Spawner surveys began on September 28, 1998, and continued through January 29, 1999, to encompass the range of spawner timing of all species of interest. Surveys were conducted once a week, weather and stream flows permitting. We utilized index reaches above and below the dam already established by WDFW personnel. We established three additional index reaches above the dam using topographical maps, recommendations from WDFW biologist, and ground surveys of the area for hospitable spawning habitat. These reaches are located from RKm 3.77-4.99 in the mainstem, RKm 0.5-1.3 on the north fork, and from RKm 0.5-1.3 on an unnamed tributary to the north fork.

Surveyors started at a downstream reference point and moved upstream to the end of the index reach. Surveyors counted and identified all salmonids, dead or alive. The caudal fin was removed from carcasses to ensure they were not recounted during future surveys. Surveyors also estimated the percentage of salmonids actually observed, taking into consideration flows, turbidity and pool depth.

Index reaches at RKm 0.8-3.5 of the mainstem and RKm 0.0-0.5 on Coffee Creek were surveyed for chum, coho, and chinook salmon. Index reaches above the dam, RKm 3.8-5.0 on the mainstem, RKm 16-17.7 on the south fork, RKm 0.5-1.3 on the north fork, and RKm 0.5-1.3 on an unnamed tributary to the north fork, were surveyed for coho and chinook salmon.

Survey data were summarized and sent to WDFW for estimations of spawner escapement using area-under-the-curve methodology (AUC). AUC's are developed by graphing live fish counts obtained during the surveys for each date a survey was completed. The area under the drawn curve estimates the number of fish days for that particular index section. Spawner abundance is estimated by dividing the number of fish days by the expected stream life of the fish. AUC uses 10 days stream life for chum and chinook salmon, and one day for coho salmon, since little is known about coho salmon stream life. Thus, chum salmon and chinook salmon spawner estimates are in actual fish, while coho salmon spawner estimates are in fish days.

WDFW calculates two AUC estimates for chum salmon spawners. One AUC estimate uses the actual number of fish observed. A second AUC estimate uses an adjusted live count. The adjusted live count is calculated by dividing the actual live count by the estimated percentage of fish observed during each survey.

Survey data were differentiated into proportions of spawning occurring above and below the dam.

Results

Chinook salmon

Spawner surveys commenced the week of September 28, 1998. However, as part of another study, Service personnel documented chinook salmon spawning in Goldsborough Creek below the dam during the week of September 21, 1998, observing at least eight redds and one spawned out female chinook salmon (C. Cook-Tabor, USFWS, personal communication). Because chinook salmon were found prior to the beginning of our spawner surveys, we are unable to determine when chinook salmon began entering the system. A total of 13 chinook salmon were observed during the survey, nine above the SR101 bridge, and four below the bridge. The highest single fish count was eight chinook on October 8, 1998. AUC estimated a total of 101 fish days with a total of 10 chinook salmon spawners (Figure 2A). AUC estimates are different than the actual observed fish because AUC takes into account stream life. All of the chinook salmon observed were found below the dam, with 69% found within the affected reach of the proposed project site. No chinook salmon were observed in any survey after October 22.

Coho salmon

Five live coho salmon and no carcasses were observed in the South Fork of Goldsborough Creek during WDFW surveys. This count was expanded by AUC methods to 47 fish with an estimated 47 fish days (Figure 2B). Spawner surveys performed by the Service and Squaxin Island Tribal personnel above the dam on the mainstem and North Fork Goldsborough Creek resulted in no salmonids observed. However, one coho salmon and one unidentified adult salmonid were observed by Service personnel at the top of the fish ladder. WDFW surveys conducted in the mainstem below the dam target chum salmon, but other species, such as coho salmon, are also counted. Due to high flows encountered, only two surveys were conducted below the dam in the mainstem of Goldsborough Creek. During these two surveys, WDFW personnel counted 12 coho salmon on December 21, 1998, and six coho salmon on January 7, 1999. Fish days could not be estimated using AUC because of the lack of data points (Figure 2C). The fish count for Coffee Creek by the AUC method was expanded to 44 coho salmon and 44 fish days (Figure 2D).

Chum salmon

Chum salmon were observed below the dam during the first survey on September 28, 1998, and it is likely that chum salmon were in the system before then. No chum salmon were observed above the dam. Chum salmon surveys on Goldsborough Creek resulted in a total of 1,697 actual fish and 16,974 fish days (Figure 2E). The adjusted live count for chum salmon was 2,281 fish and 22,841 fish days. The highest count of chum salmon was observed on December 21, with a live count of 600 chum salmon. Estimates using AUC for Coffee Creek resulted in 583 actual fish and 5,830 fish days (Figure 2F). The adjusted estimate for chum salmon in Coffee Creek was 688 fish and 6,878 fish days.

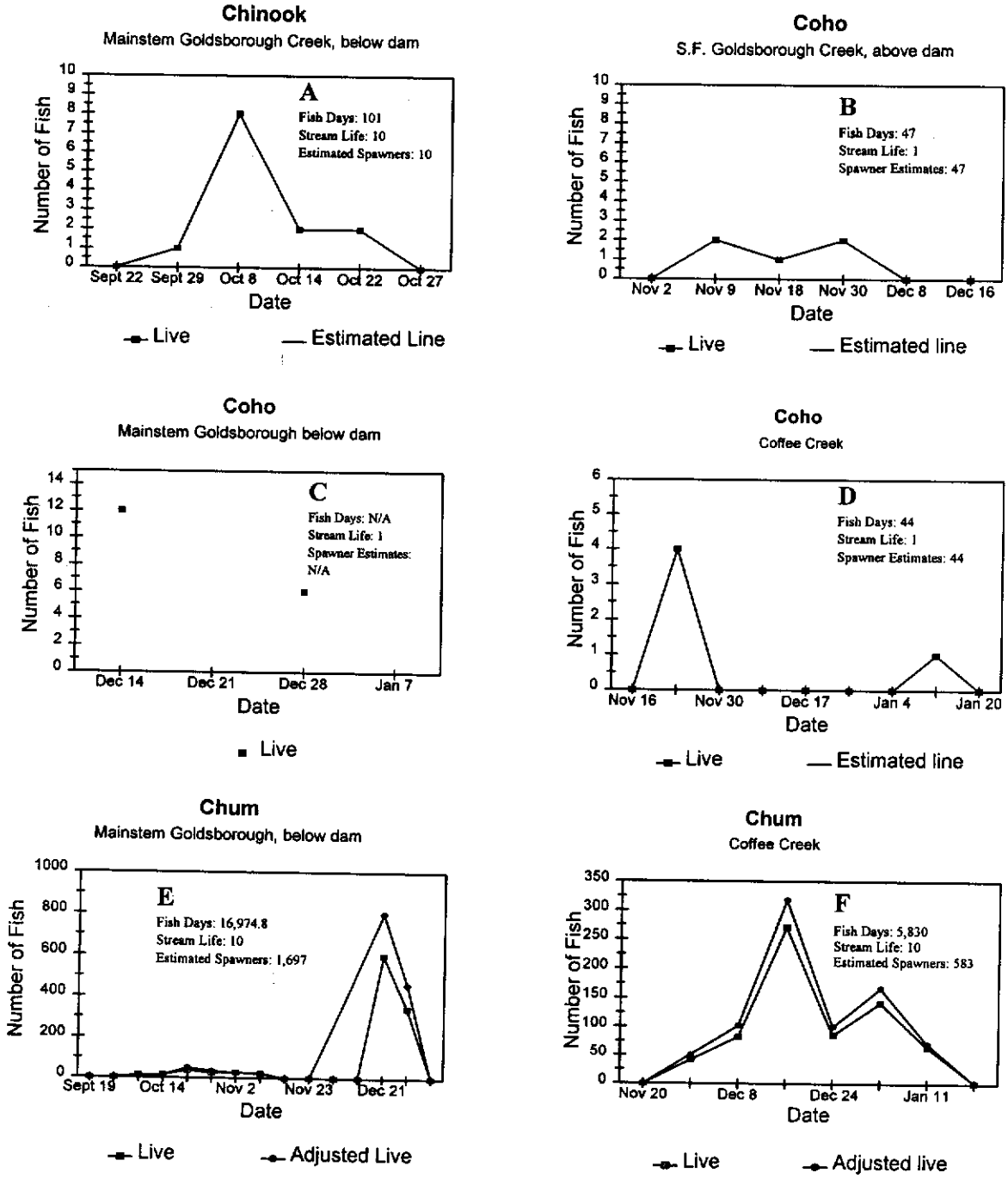

Figure 2. Area-under-the-curve estimates for Goldsborough Creek indices; A-Mainstem Goldsborough Creek chinook salmon survey; B-South Fork Goldsborough Creek coho salmon survey; C-Mainstem Goldsborough Creek coho salmon survey; D-Coffee Creek coho salmon survey; E-Mainstem Goldsborough Creek chum salmon survey; F-Coffee Creek chum salmon survey.

Discussion

Weather played a key role in coho and chum salmon spawner surveys this season. Unfortunately, surveys on the mainstem were suspended due to high flows and poor visibility during the weeks of November 16, 23, 30; December 7, 21; and January 5, 11, 19, and 25. This was a result of record rainfall during this period.

There are little or no historic data for chinook salmon in Goldsborough Creek. It is possible the chinook salmon observed were strays from the Squaxin Island Tribal net pens or from egg tubes planted by a local co-op program. Next year, scale samples will be taken from chinook salmon carcasses to try to determine if the chinook salmon are a resident population or a product of artificial propagation. Of the chinook salmon observed, 69% were found within the affected reach of the proposed project site. If chinook salmon are not able to use the restored reach for spawning, there may be a significant adverse impact to the chinook salmon population. Therefore, extreme caution should be used when developing the restored reach.

Coho salmon appear to be the only species of salmonids that use the fish ladder, but they appear to have varying success. Flows in the fish ladder are controlled by a wooden structure; however, the Service is unsure how often the flow control device is monitored or adjusted to accommodate varying flow regimes. Recent historic data (within five years) show that coho salmon use the ladder in some years. AUC estimates above the dam indicate a maximum of 544 fish days in 1994, but a minimum of zero in 1993 and 1996. WDFW has released 100,000 coho salmon fry above the dam in the South Fork Goldsborough Creek since 1985, but those fry plants were discontinued as of 1999. Also, 45,000 coho salmon eggs have been planted in egg tubes in Goldsborough Creek as part of a local high school co-op program. Even though only two surveys were completed below the dam, we still observed 78% of the live adult coho salmon spawners below the dam. The low numbers of fish observed above the dam suggests that the current fish passage is possibly inadequate, or that the wooden structure which regulates flow down the fish ladder is not adequately monitored. Dam removal and restoration of the affected reach could potentially allow more coho salmon to migrate and spawn in the upper reaches of the Goldsborough watershed.

Chum salmon were observed spawning in Goldsborough Creek as early as September 28, 1998. Most of the early chum salmon were spawning upstream of the SR101 overpass within the proposed project site. Since this is the first year spawner surveys were conducted before the first week in December, the Service is unsure if this is an early group of chum spawners or if this group of chum are strays from nearby systems. The late run of chum salmon tends to enter the system in December and spawn in the lower reaches of the creek below the SR101 bridge (R. Egan, WDFW, personal communication). With only two surveys conducted after November 9, 1998, we were unable to determine when the peak of chum salmon spawning occurred. The Service is planning on beginning spawner surveys in mid-September, 1999.

A majority of early chum and chinook salmon spawned in the area where the fill will be placed for the new channel. Therefore, it is essential that the channel be passable, or that it provide spawning habitat for these fish. Otherwise, a significant proportion of their spawning habitat will be lost.

Acknowledgments

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Appendix

Directions for spawner surveys

The first index (RKm 0.8-3.5) starts at the 7th Avenue bridge in Shelton and ends at the dam. The second index reach (Rkm 3.77-4.99) can be accessed from the railroad alongside the dam. Park a vehicle at the dam and walk up the railroad tracks. The survey begins where the railroad tracks cross Goldsborough Creek and continues approximately 1.2 kilometers. Red and pink flags mark the end of the survey reach. The third index reach is located in a tributary to the North Fork of Goldsborough Creek. Follow the Shelton-Matlock road west approximately 7 miles from Shelton. Turn left on Highland Road and follow Highland Road for 0.5 miles. Turn left after crossing the creek into the driveway. Check with landowner and let them know what you are doing. Walk down landowner's fence line and enter stream through gate. Follow stream up to Highland Road. Cross the road and enter through gate, this is a small section. Exit stream at fence and walk back to vehicle. Make a right on Highland Road after leaving that residence.

Drive about 100 meters and make a left into driveway. You should be able to see a barn from the road. Drive up and park near barn. This is the Lykes residence. Walk south through field until you reach the creek. Follow creek until it forks. Follow the right branch until you reach a small pond. Follow the left branch until you reach a wooden bridge. Walk back to barn, pick up vehicle and leave residence. Make a right on Highland Road. Follow Highland Road until you reach Little Egypt Road. Veer left on little Egypt road. Follow Little Egypt road for approximately one mile. There will be a sharp bend in the road. Instead of following paved road around bend, drive up gravel road until it crosses the creek. Park there, making sure not to block traffic. This index reach is RKm 16-17.7. Send one person upstream and the other person downstream.

Ecosystem Health of Goldsborough Creek, Washington, Based on a Benthic Index of Biotic Integrity

David Low, Roger J. Peters, Brian R. Missildine

Introduction

The Benthic Index of Biotic Integrity (BIBI) is a technique that uses benthic macroinvertebrates to evaluate stream health. The BIBI is a community-based method that requires minimal sampling, has been used to examine the health of river basins (Karr 1981; Angermeier and Karr 1986) and is more sensitive than other indices (Angermeier and Karr 1986; Hughes and Gammon 1987). This tool is much more sensitive than biological measures of fish production and provides insight into overall ecosystem health. The BIBI consists of several metrics (Table 1) which display a definite response to habitat degradation. The BIBI provides a final score from these metrics (Table 2) which defines ecosystem health. Kleindl (1995) developed a BIBI for Puget Sound lowland streams, which was able to distinguish levels of degradation. This BIBI utilizes nine metrics and provides a score ranging from nine to forty-five, with lower numbers representing poorest ecosystem health.

The objectives of this project were to determine ecosystem health above and below Goldsborough Dam based on the Puget Sound lowland BIBI which will provide baseline data for post dam-removal monitoring.

Table 1. Metrics and scoring criteria for each metric in the Puget Sound BIBI. (Adapted from Kleindl 1995).

Metric	Metric Scores		
	1 if...	**3** if...	**5** if...
1. Taxa Richness	< 10.0	10.0-20.0	> 20.0
2. Ephemeroptera Richness	< 3.0	3.0-5.5	> 5.5
3. Plecoptera Richness	< 3.0	3.0-6.0	> 6.0
4. Trichoptera Richness	< 2.0	2.0-4.5	> 4.5
5. Intolerant Taxa Richness	< 0.5	0.5-2.0	> 2.0
6. Long-lived Taxa Richness	< 0.5	0.5-2.0	> 2.0
7. % Planaria & Amphipoda Abundance	< 5%	5%-20%	> 20%
8. % Tolerant Taxa	> 50%	20%-50%	< 20%
9. % Predator Taxa	< 15%	15%-30%	> 30%

Table 2. Total BIBI scores, integrity classes and the attributes of those classes. (Adapted from Kleindl 1995).

Total BIBI score (sum of the 9 metric ratings)	**Integrity Class**	**Attribute**
39-45	Excellent	Comparable to the best conditions without human disturbance; includes most intolerant taxa, long-lived taxa are present, high richness within dominant orders and overall taxa and large proportion of predators within trophic hierarchy.
32-38	Good	Lower taxa richness, loss of most intolerant and long-lived taxa, however, richness is still high across major orders.
25-31	Fair	Loss of intolerant taxa as well as some of the intermediately tolerant taxa, lower proportion of predator richness.
18-24	Poor	Loss of most of the intermediate tolerant taxa including loss of entire orders leading to a higher proportion of highly tolerant taxa.
9-18	Very Poor	Loss of most major orders, very low species richness, loss of nearly all predators, highly tolerant taxa remain.

Methods

We collected benthic macroinvertebrate samples from four locations in Goldsborough Creek (Figure 1). Two sites, 1 and 4, were selected to represent the current state of the creek above and below the dam. Both sites are located in areas not to be directly affected by the proposed restoration. Two additional sites, 2 and 3, are both within the proposed restored reach and will provide comparisons of current health of this reach to post restoration conditions. Site 2 is below the dam and site 3 above.

Site 1 is located approximately 100 m upstream of the Hwy. 101 bridge (Figure 1). Site 2 is located below the dam approximately 200 m downstream, well within the affected range of the proposed restoration project. Site 3 is approximately 200 m above the dam, just above the Simpson Railroad Bridge. This site is potentially within range of the area to be directly affected

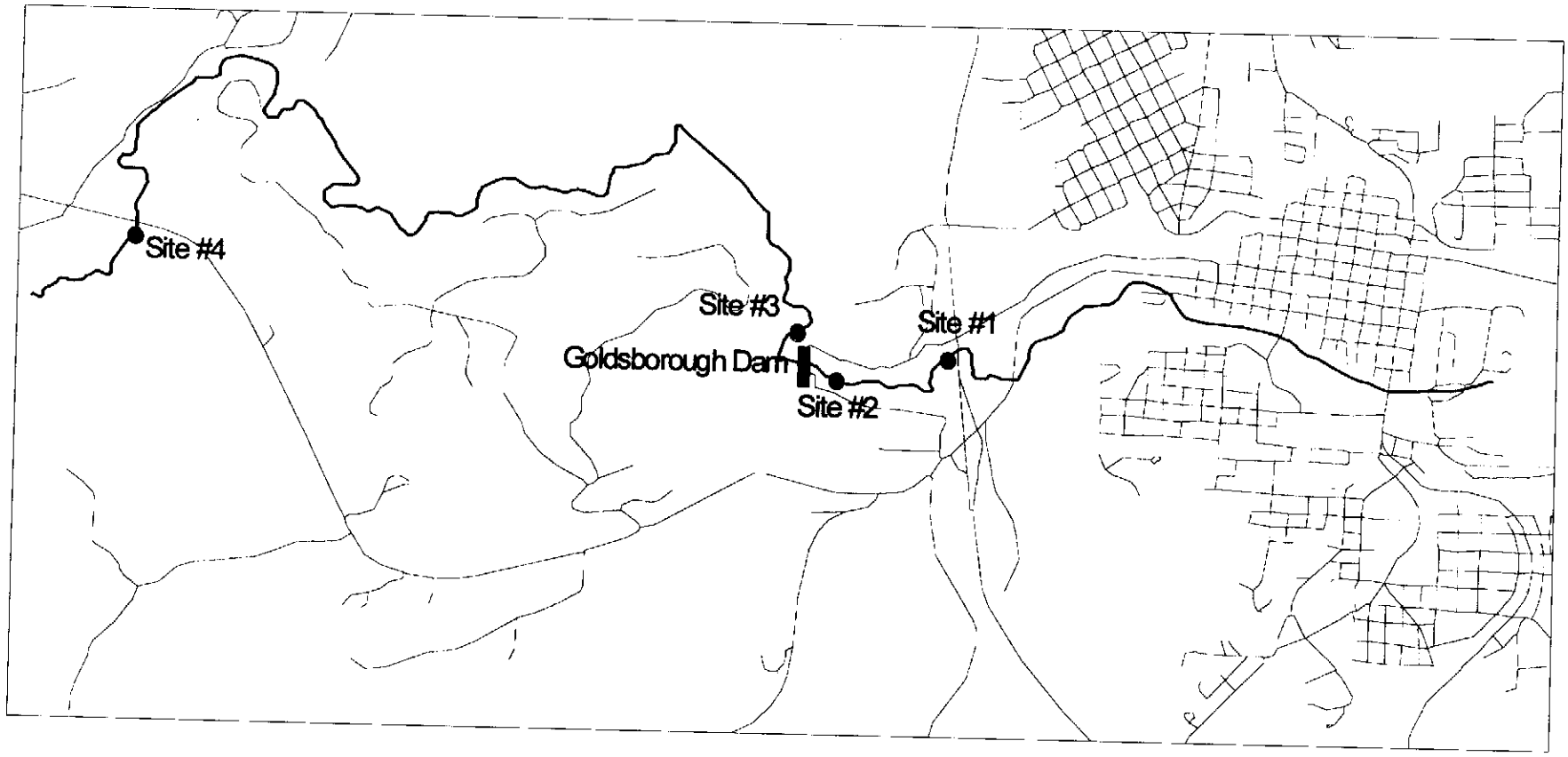

Figure 1. Benthic macroinvertebrate sample locations in Goldsborough Creek.

by removal of the dam. And the uppermost site, 4, is located several hundred meters above the Shelton/Matlock Road bridge.

Invertebrate samples were collected from a riffle at each sample site using a modified Surber sampler. We sampled riffle habitats, which support the richest community of benthic invertebrates (Cuffney et al. 1993). The sample net was 450μm mesh net with a detachable sample bucket and a $0.25m^2$ frame attached to the front to insure consistent sampling area. Each sample consisted of a combination of three Surber samples collected from different locations within the riffle, one located at the head, one in the middle, and one near the tail of the riffle. These three locations allowed us to sample significantly different velocities: fast water, moderate velocity, and low velocity sections of the riffle. The sampler was placed on the substrate and held in place while an individual brushed the invertebrates from the larger rocks into the net. After the largest rocks were brushed clean, a metal rod was used to disturb the sediments down to a depth of 10 cm. A minimum of three minutes was required to collect each sample to insure that the majority of the invertebrates were collected. The sample was then rinsed into a detachable collection bottle at the end of the net, poured into a 450-μm sieve, rinsed, placed in a sample jar, and preserved using 70% alcohol.

All preserved samples were shipped to Eco Analysts, Inc. of McCall, Idaho, for subsampling, sorting, and identification. Eco Analysts sorted and identified at least 500 aquatic macroinvertebrates per sample, provided estimates of abundance, community profile, and summary statistics, including metrics for the BIBI. Subsampling was completed using a Caton sorting tray. At least 300 additional invertebrates were obtained if the sample was dominated by a single taxon. Most insects were identified to genus or species. Difficult groups were identified to family.

After invertebrate sample collection, physical data were collected at each site using a Hydrolab unit. We measured water temperature, dissolved oxygen, specific conductivity and total dissolved solids. Wetted width and riffle lengths were measured using a Bushnell Lytespeed 400 laser range finder. We measured depth, velocity, substrate composition, embedded score, and wetted width at each replicate. We also noted location within the riffle. Depth was recorded using a stadia rod to the nearest tenth of a meter. Velocity was recorded using a Swouffer Model 201 current meter. Substrate was characterized into percent of fine sediments, gravel, cobble, boulder or bedrock (Cummins 1962). Embeddedness was scored as < 5%, 5-25%, 25-50%, 50-75% and > 75%.

We used the BIBI developed for Puget Sound lowland streams to determine the health or status of Goldsborough Creek (Kleindl 1995). We calculated the BIBI score at each site based on the metrics developed by Kleindl (1995) (Tables 1 and 2). We compared BIBI scores from Goldsborough Creek with two local streams, Schneider Creek and Percival Creek, and the Puget Sound lowland creeks Kleindl (1995) used to develop the index.

Results and Discussion

The BIBI scores ranged from 29 to 37 (Table 3). Sites 1 (35) and 4 (37) are within the range considered "Good" in the index (Table 2). Sites 2 (29) and 3 (29) are within the range for "Fair" in the index (Table 2). The differences among and between sites can be partially explained by the effects created by the dam. Sample 2 below the dam is in an area where the channel is degrading. The dam has prevented the delivery of sediments to this area. This prevents the creek from stabilizing to a point where invertebrate communities can sufficiently colonize this area. Site 3 above the dam is in an area also affected by the dam. Sediments trapped by the dam have been building up over the years causing the channel to aggrade and continually readjust. This is reflected in the data (Table 3) by the sixth metric, Long-lived Taxa Richness. These two sites have lower values for this metric than sites 1 and 4.

Table 3. BIBI scores for the four Goldsborough Creek sites.

	BIBI Score			
Metric	**Site 1**	**Site 2**	**Site 3**	**Site 4**
1. Taxa Richness	5	5	5	5
2. Ephemeroptera Richness	5	3	3	5
3. Plecoptera Richness	5	3	5	5
4. Trichoptera Richness	5	5	5	5
5. Intolerant Taxa Richness	3	3	1	3
6. Long-lived Taxa Richness	3	1	1	3
7. % Planaria & Amphipoda Abundance	1	1	1	1
8. % Tolerant Taxa	5	5	5	5
9. % Predator Taxa	3	3	3	5
Total	35	29	29	37

Site 1 is located downstream where the effects of the dam are less noticeable. The creek is able to regain some of the bedload by stripping the banks of sediment. The channel, while still degrading, has more sediment delivery and more complex structure than at site 2. Site 4, located several miles above the dam, is not affected by the dam. The channel in this reach is relatively stable and a much more natural system exists. This is reflected in the BIBI score which was the highest of the four sites.

We compared the Goldsborough Creek scores with scores from two other streams in the area, Schneider Creek and Percival Creek, from Kleindl (1995). It appears that he incorrectly labeled one creek as the other in his report, given the creek descriptions he provides. One sample was taken in Percival Creek and received a score of 23. Two samples were collected by Kleindl in Schneider Creek to represent a change in land use. The sample from the lower basin received a score of 27 and the sample from the upper basin a score of 23. Percival Creek fell into the "Poor" integrity class and Schneider Creek samples showed "Poor" and "Fair" integrity. Goldsborough Creek was classified as "Fair" in the vicinity of the dam and "Good" at the outer sites.

Percival Creek is a small basin in a heavily urbanized system entirely within the city limits of Olympia. Schneider Creek runs next to Highway 101 for most of the lower half of the creek. The basin includes several wetlands and small lakes. The basin has been heavily logged and riparian areas are sparse in places. Goldsborough Creek also contains numerous small lakes and wetlands within its basin, but riparian areas are more intact throughout the upper watershed. This would account for the higher BIBI scores noted in Goldsborough Creek.

Goldsborough Creek ranked above average when compared with all Puget Sound lowland streams sampled by Kleindl (1995). The nineteen streams in his study had scores ranging from nine to forty-three. The metrics developed were based on samples collected from four streams in Puget Sound. None of them were considered pristine. This has biased the index toward less pristine streams, setting low benchmarks and probably accounting for the higher scores that Goldsborough Creek exhibits. Thus, Goldsborough Creek ranks high for streams in Puget Sound, but would likely receive a lower ranking in an index with metrics from more pristine creeks.

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